ASSESSMENT REPORT ON

ACRYLIC ACID

FOR DEVELOPING AN AMBIENT AIR QUALITY GUIDELINE

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FOREWORD

Alberta Environment maintains Ambient Air Quality Guidelines to support air quality management in Alberta. Alberta Environment currently has ambient guidelines for thirty-one substances and five related parameters. These guidelines are periodically updated and new guidelines are developed as required. Fact Sheets on Ambient Air Quality Guidelines were updated in September 1997 and February 2000.

With the assistance of the Clean Air Strategic Alliance, a multi-stakeholder workshop was held in October 2000 to set Alberta's priorities for the next three years. Based on those recommendations, a three-year work plan ending March 31, 2004 was developed to review four existing guidelines, create three new guidelines for three families of substances, and adopt six new guidelines from other jurisdictions.

This document is one in a series of documents that presents the scientific assessment for these substances.

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104-02451/

SUMMARY

Acrylic acid is a colourless liquid with an irritating acrid odour. When emitted into the atmosphere, it will react with photochemically produced hydroxyl radicals and ozone, resulting in rapid degradation. The atmospheric lifetime of acrylic acid is less than one month.

Acrylic acid is used primarily as a starting material in the production of acrylic esters, as a monomer for polyacrylic acid and salts and as a co-monomer with acrylamide for polymers used as flocculants, with ethylene for ion-exchange resin polymers, and with methyl ester for polymers. The major industrial sectors contributing to acrylic acid emissions in Canada are the chemical and chemical products sector and the plastic products industries. The National Pollutant Release Inventory reports that there are no major emissions of acrylic acid from industrial facilities in Alberta.

No published literature could be found on the direct effects (through the atmosphere) of acrylic acid exposure to terrestrial plants. The primary route of acrylic acid exposure for the general public and animals would be through inhalation. However, it is unlikely that significant exposure to acrylic acid would occur in the absence of an industrial source or hazardous waste facility emitting this substance.

Short-term (5-hour) inhalation exposure to 17,700 mg/m^3 (6,000 ppm) acrylic acid has caused irritation of the eyes and nose, lung hemorrhage, and some systemic damage to the liver and kidneys in rats. Similar systemic effects have not been reported in humans, and are considered unlikely due to acrylic acid's strong irritant properties. No effects of acute toxicity in humans from inhalation are reported. Rats and mice exposed to acrylic acid by inhalation under longer conditions (5 to 13 weeks) have demonstrated eye, nose and skin irritation, degeneration of the nasal epithelium, reduced food consumption, and reduced weight gain at concentrations ranging from 15 to 700 mg/m^3 (5 to 238 ppm). No similar effects of chronic toxicity in humans are identified. Limited studies examining the potential carcinogenicity of acrylic acid are inadequate to determine human carcinogenicity. However, the current practice requires strong evidence to conclude that a chemical is not carcinogenic in humans, usually including adequate chronic bioassays in at least two species. Based on the lack of this type of data, it cannot be definitively concluded that acrylic acid causes cancer in humans, although substantial relevant data suggest that it does not.

Several agencies reviewed as part of this assessment have an air quality guideline for acrylic acid for acute (. 24 hours) exposure conditions. The California Environmental Protection Agency adopted a 1-hour guideline based upon nasal irritation in rats (6,000 $\mu g/m^3$ or 2,040 ppb). In addition, two agencies in the U.S. (Ohio Environmental Protection Agency and Texas Natural Resources Conservation Commission) use a 1-hour guideline of 59 $\mu g/m^3$ (20 ppb). This guideline is derived from taking the American Conference of Governmental Industrial Hygienists Permissible Exposure Limit of 5,900 $\mu g/m^3$ (2,000 ppb) and dividing it by safety or adjustment factors. Another four agencies adopted 24-hour guidelines ranging from 1 to 141 $\mu g/m^3$ (0.34 to 48 ppb). The approaches used by these four agencies in developing their guidelines involve using non-carcinogenic risk assessment procedures or taking the American

Conference of Governmental Industrial Hygienists Permissible Exposure Limit and dividing it by safety or adjustment factors.

Five agencies reviewed use a chronic guideline for non-carcinogenic effects. This guideline is based upon the US Environmental Protection Agency's dose-response data for a non-cancer endpoint – 1 $\mu g/m^3$ (0.34 ppb).

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1.0 INTRODUCTION

Alberta Environment establishes Ambient Air Quality Guidelines under Section 14 of the *Environmental Protection and Enhancement Act* (EPEA). These guidelines are part of the Alberta air quality management system (AENV, 2000).

The main objective of this assessment report is to provide a review of scientific and technical information to assist in evaluating the basis and background for an ambient air quality guideline for acrylic acid. The following aspects were examined as part of the review:

- physical and chemical properties,
- existing and potential natural and anthropogenic emissions sources in Alberta,
- effects on humans, animals, and vegetation,
- monitoring techniques,
- ambient air guidelines in other Canadian jurisdictions, United States, European Union and Australia, and the basis for development and use.

Important physical and chemical properties that govern the behaviour of acrylic acid in the environment include, but are not limited to, chemical structure, molecular weight, melting and boiling points, water solubility, density, vapor density, organic carbon partition coefficient, octanol water partition coefficient, vapor pressure, Henry's Law constant, bioconcentration factor, and odor threshold. Values for these properties will be reviewed and presented.

Existing and potential natural and anthropogenic sources of acrylic acid emissions in Alberta will also be presented. Natural emissions of acrylic acid are described in the literature. Anthropogenic emissions are provided in Environment Canada's National Pollutant Release Inventory (NPRI).

Scientific information about the effects of acrylic acid on humans and animals is reported in published literature and other sources. This information includes toxicological studies published in professional journals and reviews and information available through the International Programme on Chemical Safety (IPCS), US Department of Health and Human Services' Registry of Toxic Effects on Chemical Substances, and US Environmental Protection Agency's Integrated Risk Information System. All of these sources provide valuable information for understanding health effects of acrylic acid exposure.

Reference air monitoring and other techniques for detecting acrylic acid in air are also documented in published literature. In particular, several widely employed and accepted referenced air monitoring methods exist for acrylic acid. These methods have been developed, tested and reported by US Environmental Protection Agency and US Occupational Safety and Health Administration (OSHA).

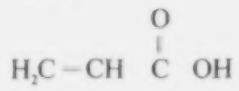
2.0 GENERAL SUBSTANCE INFORMATION

Acrylic acid is a clear, colourless liquid at room temperature and pressure (IPCS, 1997; Cascieri and Clary, 1993). Its odour has been described as irritating (IPCS, 1997), acrid (Lewis, 2000; Patnaik, 1999; IPCS, 1997; Merck, 1996), pungent (Cascieri and Clary, 1993), rancid and sweet (Verschueren, 1996).

Acrylic acid is a moderately strong carboxylic acid (Bauer, 1991). It is corrosive (Lewis, 2000;IPCS, 1997; Merck, 1996; Cascieri and Clary, 1993) and flammable (Lewis, 2000) and may become explosive if confined (Lewis, 2000). Decomposition of acrylic acid may produce carbon monoxide (Genium, 1999). Acrylic acid may undergo exothermic polymerization (Lewis, 2000) if exposed to heat or low oxygen atmosphere, if contaminated or if an inhibitor is not properly added (Genium, 1999).

Table 2-1 provides a list of important identification numbers and common synonyms for acrylic acid.

Table 2-1 Identification of Acrylic Acid

Property	Value
Formula	$C_3H_4O_2$
Structure	
CAS Registry number	79-10-7
RTECS number	AS4375000
UN Number	UN 2218
Common Synonyms	acroleic acid ethene carboxylic acid ethylene carboxylic acid glacial acrylic acid propene acid 2-Propenoic acid (CAS name) propenoic acid RCRA Waste Number u008 vinylformic acid

Acrylic acid is used primarily as a starting material in the production of acrylic esters and as a monomer for polyacrylic and polymethacrylic acids and salts (Genium, 1999; IPCS, 1997). It is also used as a co-monomer for polymers used as flocculants (IPCS, 1997) and for polymers used in molding powder for signs, construction units, decorative emblems and insignias (Genium, 1999). Acrylic acid is used in the manufacturing of plastics, as a tackifier, in polymer solutions for coatings, in paint formulations for leather finishing, in paper coatings, in polishes and adhesives and in general finishes and binders (Genium, 1999). It is also used with ethylene for

ion-exchange resin polymers, and with methyl ester and methylene succinic acid for polymers and co-polymers (IPCS, 1997).

In a non-industrial setting, acrylic acid and sodium acrylate have been used as silage additives to retard fermentation and protein breakdown (Wilson et al., 1978, 1979). Linear polyacrylamide (PAM) is gaining considerable acceptance as an effective anti-erosion additive in irrigation waters (Kay-Shoemake et al., 1998). There have also been attempts to use polyacrylamide to protect seeds against chilling stress (Knypl and Knypl, 1993) and as a foliar or soil drench to induce plant disease resistance to fungal and viral pathogens (Cassells and Flynn, 1978).

2.1 Physical, Chemical and Biological Properties

The physical and chemical properties of acrylic acid are summarized in Table 2-2.

2.2 Environmental Fate

The environmental fate of acrylic acid is summarized in Table 2-3. When acrylic acid is released into the atmosphere, it undergoes both chemical and photochemical reactions. Chemical reactions include rapid polymerization in the presence of oxygen (US EPA, 1984). Acrylic acid will react photochemically with hydroxyl radicals and ozone. Reaction of acrylic acid with ozone produces glyoxylic acid and formic acid as intermediates and hydrogen peroxide and citric acid as end products (US EPA, 1984). The atmospheric lifetime of acrylic acid is less than one month (IPCS, 1997).

Acrylic acid released to water will undergo microbial degradation, chemical and photochemical reactions (US EPA, 1984). Acrylic acid is biodegradable (US EPA, 1984). In aqueous solutions, acrylic acid may polymerize in the presence of oxygen or may undergo UV irradiation. UV irradiation in the presence of NH_3 or N_2 has shown to result in the formation of amino acids; however, this reaction is inhibited by H_2. Due to its low vapour pressure, low octanol/water partition coefficient and high solubility, acrylic acid will remain in the dissolved state (US EPA, 1984).

Acrylic acid released to soil may undergo microbial degradation (Howard, 1989; US EPA, 1984). Due to its low vapour pressure and high water solubility, acrylic acid will not sorb to soil or volatilize from soil (US EPA, 1984). It is expected that acrylic acid will leach into the groundwater and runoff to surface water (Howard, 1989; US EPA, 1984). Bioaccumulation is considered negligible (Richardson, 1992).

Table 2-2 Physical and Chemical Properties of Acrylic Acid

Property	Value	Reference
Molecular Weight	72.06	Lide, 2001; Verschueren, 2001
Physical state	Liquid	
Melting Point	12.3 °C	Lide, 2001
	12-14 °C	Verschueren, 2001
	14 °C	Howard, 1989
Boiling Point	141 °C	Lide, 2001; Verschueren, 2001
	141 °C (polymerizes)	Lewis, 2000; Richardson, 1992
	141.6 °C	Howard, 1989
Specific gravity (liquid)	1.05 at 20 °C	Lide, 2001; Genium, 1999
	1.06 at 16 °C	Verschueren, 2001; Richardson, 1992
Specific gravity (gas) (air =1)	2.5	Verschueren, 2001; Genium, 1999
	2.45	Lewis, 2000; Richardson, 1992
Vapour pressure	3.8 hPa (3.2 mm Hg) at 20 °C	Verschueren, 2001
	7.76 mm Hg at 20 °C	Howard, 1989
Solubility in water	Miscible	Genium, 1999; Howard, 1989
	$1.0x10^9$ µg/L	MDEQ, 2002
Solubility	Miscible in alcohol, benzene, chloroform, ether, acetone, DMSO	Lewis, 2000; Genium, 1999
Pka	4.3	Bauer, 1991; US EPA 1984
	4.247	Howard, 1989
Henry's Law Constant	$3.2x10^{-7}$	Genium, 1999; Howard, 1989
Octanol water partition coefficient (log K_{ow})	0.31-0.46	Verschueren, 2001
	0.36	Genium, 1999
	0.161-0.46	IPCS, 1997
	0.31/0.43	Richardson, 1992
	0.161	Howard, 1989
Organic carbon partition coefficient (K_{oc})	2.21 L/kg	MDEQ, 2002
	Not estimated due to ionization	SRC, 1988
	43	HSDB, 2002
Flash Point	54 °C (open cup)	Genium, 1999
	46-52 °C (closed cup)	INRS, 1997
Explosive limits	2.4% to 8.04%	Genium, 1999
Autoignition temperature	438 °C	Genium, 1999
	390-446 °C	IPCS, 1997
Odour threshold	0.094 ppm (absolute)	Verschueren, 2001
	1.04 ppm (100% recognition)	
	1.04 ppm (recognition)	Genium, 1999
	0.06 ppm to 1.0 ppm	California OEHHA, 1999
	94 ppb	Bauer, 1991
	0.20-3.14 mg/m^3	IPCS, 1997
Bioconcentration factor in fish (log BCF)	0.78	Genium, 1999; Richardson, 1992; Howard, 1989
	-0.11	SRC, 1988
Conversion factors for vapour (at 25 °C and 101 3 kPa)	1 $µg/m^3$ = 0.34 ppb	Plog et al., 1996

Table 2-3 Environmental Fate of Acrylic Acid (Genium, 1999; IPCS, 1997; Richardson, 1992; Howard, 1989)

System	Fate	Half life
Water	will biodegrade in water; in aquatic systems, adsorption to sediment, volatilization and bioconcentration should be negligible	
Soil	leaches into the ground; may be degraded aerobically or anaerobically;	
Air	will react with ozone and photochemically produced OH hydroxyl radicals	• *Reaction with hydroxyl radicals* 6.6 hours – 2 days • *Reaction with ozone* 7 days

3.0 EMISSION SOURCES AND INVENTORIES

3.1 Natural Sources

Acrylic acid occurs naturally in certain species of marine algae such as *Phaeocystis* and *Polysiphonia lanosa* (Verschueren, 2001; IPCS, 1997; Howard, 1989). It has been found in oysters, scallops and the digestive tract of penguins. Acrylic acid in these organisms is believed to originate from the algae on which they feed (IPCS, 1997). Acrylic acid has also been found in the stomach of sheep (IPCS, 1997; US EPA, 1994b; Howard, 1989).

3.2 Anthropogenic Sources

3.2.1 Industrial

According to the National Pollutant Release Inventory (NPRI), the industrial sectors contributing to acrylic acid emissions are the chemical and chemical products sector and the plastic products industries (NPRI, 2000). The chemical and chemical products sector includes industries producing industrial organic chemicals, plastics, resins, soaps, cleaning compounds, adhesives, and other chemical and plastic products (NPRI, 2000). The plastic products industries include the foamed and expanded plastic products industries and other plastic products industries (NPRI, 2000).

Table 3-1 and 3-2 indicate that, according to the NPRI database (NPRI, 2000), there are no facilities in Alberta emitting acrylic acid. It should be noted; however, that a facility is only required to report to the NPRI if it meets all three of the following criteria (NPRI, 1999):

- the facility has more than 10 full-time employees,
- the facility manufactured, processed or used 10 tonnes or more of an NPRI substance in the calendar year,
- the facility manufactured, processed or used an NPRI substance at a concentration greater than or equal to 1% by weight

It may be possible that acrylic acid is emitted in Alberta in such small amounts that the facilities are not required to report to NPRI. Based on the uses reported for acrylic acid in the previous section, it is unlikely that emissions occur from sectors not reporting to NPRI.

3.2.2 Other

Acrylic acid can occur in wastewater effluents as the result of the oxidation of propylene (Richardson, 1992). Trace amounts of acrylic acid have also been found in commercial propionic acid (IPCS, 1997). Acrylic acid was also detected in the emissions from polyethylene, ethylene-vinyl acetate and ethylene-methyl acrylate resins (HSDB, 2002).

Table 3-1 Total Emissions of Acrylic Acid According to NPRI, 2000 (in tonnes)

NPRI ID	Company	City	Province	Acrylic Acid Emissions (tonnes)				
				Air	Water	Land	Underground	Total
0800	Rhodia Canada Inc.	Mississauga	ON	0.27	0.00	0.00	0.00	0.27
0729	Mapei Inc.	Laval	QC	NA	NA	NA	NA	0.10*
2048	Vinings Industries Canada Inc.	St. Catharines	ON	0.10	0.00	0.00	0.00	0.10
2969	Waltec Plastics Inc.	Midland	ON	NA	NA	NA	NA	0.09*
0281	Dow Chemical Canada Inc.	Varennes	QC	0.01	0.00	0	0	0.01
2065	Rohm and Haas Canada Inc.	West Hill	ON	NA	NA	NA	NA	0.01*

*values determined based on engineering estimates

NA denotes not available

Table 3-2 Air Emissions of Acrylic Acid According to NPRI, 2000 (in tonnes)

NPRI ID	Company	City	Province	Air Emissions of Acrylic Acid (tonnes)					
				Stack /Point	Storage /Handling	Fugitive	Spills	Other Non-Point	Total
0800	Rhodia Canada Inc.	Mississauga	ON	0.00	0.23	0.04	0.00	0.00	0.27
0729	Mapei Inc.	Laval	QC	NA	NA	NA	NA	NA	NA
2048	Vinings Industries Canada Inc.	St. Catharines	ON	0.00	0.00	0.1	0.00	0.00	0.1
2969	Waltec Plastics Inc.	Midland	ON	NA	NA	NA	NA	NA	NA
0281	Dow Chemical Canada Inc.	Varennes	QC	0.00	0.007	0.006	0.00	0.00	0.01
2065	Rohm and Haas Canada Inc.	West Hill	ON	NA	NA	NA	NA	NA	NA

NA denotes not available

4.0 EFFECTS ON HUMANS AND ECOLOGICAL RECEPTORS

4.1 Humans and Animals

Typically, the primary route of exposure for the general public and the environment to acrylic acid is via inhalation from an industrial air source, although, there may be some exposure from polishes, paints, coatings, rug backings, adhesives, plastics, textiles, and paper finishes (HSDB, 1993; Sittig, 1985).

Once inhaled, acrylic acid is readily absorbed, and rapidly metabolized and excreted primarily as carbon dioxide (Kutzman et al., 1982; US EPA 1984; DeBethizy et al., 1987; D'Souza and Francis, 1988; Finch and Frederick, 1992; Winter and Sipes, 1993; Black et al., 1993; 1995; Frantz and Beskitt, 1993; IPCS, 1997). Inhalation of acrylic acid is irritating to the eyes, skin, and respiratory system in humans and animals; some acute systemic effects have been reported in animal studies (Gage, 1970; Sittig, 1985; DeBethizy et al., 1987; BG Chemie, 1991; IPCS, 1997; HSDB, 1993; US EPA, 1983; 1995; RTECS, 1993).

No systemic or chronic human effects data were available. Studies examining the potential carcinogenicity of acrylic acid were inadequate to determine human carcinogenicity (IPCS, 1997; US EPA, 1995; IARC, 1979; 1987).

4.1.1 Overview of Chemical Disposition

No human metabolic studies were available (BG Chemie, 1991; IPCS, 1997; EPA, 1995).

Metabolic studies in rats and mice indicate that after exposure, acrylic acid is readily absorbed, distributed throughout the body, and rapidly excreted primarily as carbon dioxide (Kutzman et al., 1982; DeBethizy et al., 1987; D'Souza and Francis, 1988; Finch and Frederick, 1992; Winter and Sipes, 1993; Black et al., 1993; 1995; Frantz and Beskitt, 1993). Absorption of inhaled acrylic acid occurs primarily via the gastro-intestinal tract with some absorption via the lungs (Kutzman et al., 1982; BG Chimie, 1991; IPCS, 1997). Detoxification occurs primarily in the kidney and liver with limited metabolism in other tissues throughout the body. Metabolism appears to occur via a mitochondrial biochemical pathway that normally breaks down short chain fatty acids (Kutzman et al., 1982; BG Chemie, 1991; Finch and Frederick, 1992; Black et al., 1993; Winter and Sipes, 1993; DeBethizy et al., 1987). For all routes of exposure (either inhalation, ingestion, dermal or intravenous), the primary metabolite is carbon dioxide (more than 60% of the exposure dose) that is rapidly produced and excreted in expired air within 15 minutes after exposure. The majority of the exposure dose (up to 75%) is excreted within 24 hours. Small amounts (less than 10%) of unchanged acrylic acid and other secondary metabolites are excreted in the urine and faeces (Kutzman et al., 1982; US EPA, 1984; DeBethizy et al., 1987; BG Chemie, 1991; Finch and Frederick, 1992; Winter and Sipes, 1993; Black et al., 1993; 1995; Frantz and Beskitt, 1993).

Acrylic acid's short half-life indicates no potential for bioaccumulation (IPCS, 1997).

4.1.2 Acute Effects

4.1.2.1 Acute Adverse Effects in Experimental Animals

In rats and mice, acrylic acid is moderately toxic when inhaled or ingested. Inhalation causes irritation of the eyes and nose, lung hemorrhage, and some systemic damage to the liver and kidneys. The rapid detoxification of acrylic acid may explain why there is minimal system toxicity with exposure. It is moderately to highly toxic when applied to the skin (Gage, 1970; Sittig, 1985; DeBethizy et al., 1987; BG Chemie, 1991; IPCS, 1997; HSDB, 1993; US EPA, 1983; 1995; RTECS, 1993).

Table 4-1 lists some examples of NOAELs (No Observable Adverse Effects Level) and LOAELs (Lowest Observable Adverse Effects Level) for acute inhalation exposures reported in the literature.

Table 4-1 Examples of NOAELs and LOAELs Associated with Acute Inhalation Exposures in Animal Species

Effects Reported	Exposure Period	Air Concentration mg/m^3 (ppm)[a]	Species	References
LC_{50}	2h	5,300 (1797)	Mice	RTECS, 1993.
	30 min	26,000 (8814)	Rat	Hagan and Emmons, 1991
	1h	11,110 (3766)		
	2h	7,500 (2542)		
	4h	36,000 (12,204)		Majka et al., 1974
		>5,100 (>1729)		Klimisch & Zeller, 1980
Irritation of eyes and nose, respiratory distress, unresponsiveness. One animal died with lung hemorrhage and degeneration of liver and kidney.	5h	17,700 (6,000)	Rats	Gage, 1970.
Nasal discharge, lethargy, weight loss, and congested kidneys	6h, 4d	4,425 (1,500)	Rats	
Dose-dependant decrease in respiratory volume and minute volume	1h	295; 885; 1475 (100; 300; 500)	Rats	Silver et al., 1981.
50% decrease in respiratory rate	-	2,020 (685)	Mice	Buckley et al , 1984.
	-	1,513 (513)	Rats	

[a] When study did not describe concentrations in mg/m^3 and/or ppm the following conversion factor and assumptions were used: mg/m^3 x 24.45/MW =ppm; MW=72.06, air at 25°C and 101.3 kPa (760mmHg) (Plog et al., 1996).

Acute oral LD_{50}'s have been reported to range from 193 –3200 mg/kg in rats; 830 – 1200 mg/kg in mice; up to 250 mg/kg in rabbits. Acute dermal LD_{50}'s have been reported to range from 295 – 950 mg/kg in rabbits. Acute intraperitoneal LD_{50}'s have been reported to range from 17 – 140 mg/kg in mice, and at 24 mg/kg in rats (IPCS, 1997). The variation in LD_{50}'s may be due to different forms of acrylic acid used in the various studies. Oral exposures also significantly

affected stomach and fore stomach weights at higher doses, probably due to the local irritant and corrosives effects of acrylic acid (BG Chemie, 1991; IPCS, 1997).

4.1.2.2 Acute Adverse Health Effects In Humans

Inhalation of acrylic acid, or exposure to acrylic acid vapours is irritating to the eyes, nose, and skin (Gosselin et al., 1976; HSDB, 1994; BG Chemie, 1991; IPCS, 1997; ACGIH, 2001). Any systemic effects seen in animal studies have not been reported in humans, and are considered unlikely due to acrylic acid's strong irritant properties (US EPA, 1994b).

A case of dermal hypersensitivity to acrylic acid after occupational exposure to acrylic acid and other acrylate compounds has been reported (Fowler, 1990). This effect is thought to have been due to an impurity of the acrylic acid (Waegemaekers and van der Walle, 1984; BG Chemie, 1991; IPCS, 1997).

4.1.3 Sub-Chronic and Chronic Effects

4.1.3.1 Sub-Chronic and Chronic Adverse Health Effects in Experimental Animals

The results of animal studies reporting the effects of sub-chronic and chronic exposures to acrylic acid have been reviewed and summarized (ACGIH, 2001; RTECS, 2000; BG Chemie, 1991; IPCS, 1997; US EPA, 1995; US EPA 1994a,b). Examples of the NOAELs (No Observable Adverse Effect Level) and LOAELs (Lowest Observable Adverse Effect Level) associated with inhalation exposures are described in Table 4-2.

Table 4-2 Examples of NOAELs and LOAELs Associated with Sub-Acute Inhalation Exposures in Animal Species

Effects Reported	Exposure Period	Air Concentration mg/m^3 (ppm)[a]	Species	References
Nasal irritation, lethargy, decreased weight gain NOAEL	5d/wk, 4wks	240 (80)	Rats	Gage, 1970.
Nasal irritation, lethargy, decreased body weight gain. LOAEL	6h, 4 times	4,500 (1,500)		
Decreased weight gain; NOAEL	6h/d, 5d/wk, 2 wks	225 (75)	Rats&Mice	Miller et al., 1979
Decreased adipose tissue NOAEL			Female rats	
Lesions of the nasal mucosa NOAEL			Rats	
Dose-related lesions of the nasal mucosa LOAEL		75–675 (25-223)	Mice	
Decreased mean body weights gains. NOAEL	6h/d, 5d/wk, 13wks	15 (5)	Female mice	Miller et al., 1979; 1981
Changes in organ weights, clinical chemistry, parameters, urinalysis parameters, or gross pathology. NOAEL		225 (75)		
Focal degeneration of nasal olfactory epithelium. LOAEL		≥25 (≥8.5)	Mice	
Slight focal degeneration of nasal olfactory epithelium. NOAEL		75(25)	Rats	
Degeneration of nasal olfactory epithelium LOAEL		15 (5)	Rats & Mice	
Eye and skin changes, reduced body weight, increased reticulocyte counts, reduced urine concentrating capacity, damaged gastric mucosa, and inflammation of the respiratory tract. LOAEL	4h/d, 5wks	702 (238)	Rats	Majka et al., 1974
Degeneration of the nasal mucosa. NOAEL	6h/d, 5d/wk, 2wks	218 (74)		US EPA, 1994c
Histopathological lesions in the nasal cavity. NOAEL	6h/d, 2wks	15(5)	Female Mice	Lomax et al., 1994.
Histopathological lesions in the olfactory epithelium. LOAEL	22h/d, 2wks	75(25)		
Histopathological lesions in the olfactory epithelium LOAEL.	4.4h/d, 2wks			

Table 4-2 Examples of NOAELs and LOAELs Associated with Sub-Acute Inhalation Exposures in Animal Species (continued)

Effects Reported	Exposure Period	Air Concentration mg/m^3 (ppm)[a]	Species	References
Maternal toxicity (nasal and eye irritation, decreased food consumption, restlessness). LOAEL	6h/d, 10 days, day 6-15 of gestation.	354 (120)	Pregnant rats	Klimisch and Hellwig, 1991.
Adverse fetal effects (pre-implantations, live fetuses and resorptions, fetal size, or morphological abnormalities) NOAEL		1,062 (360)		
Maternal toxicity (nasal irritation, reduced body weight) NOAEL	6h/d, day 10-23 of gestation	180 (60)	Pregnant Rabbits	Chun et al., 1993.
Final body weight gain (dose related with significant effects at highest dose) LOAEL		90 (30)		
Maternal lesions in the squamous metaplasia, epithelial erosion, ulceration of the epithelium. LOAEL		90 (30)		
Maternal Toxicity (nasal irritation and congestion, decreased food consumption) NOAEL	6h/d, day 6-18 of gestation	75 (25)		Neeper-Bradley and Kubena, 1993
Adverse fetal effects (# corpora lutea and total viable or nonviable implantations, preimplantation loss, fetal length or weight, morphological abnormalities). NOAEL		675 (225)		

[a] When study did not describe concentrations in mg/m^3 and/or ppm the following conversion factor and assumptions were used: mg/m^3 x 24.45/MW =ppm; MW=72.06, air at 25°C and 101.3 kPa (760mmHg) (Plog et al., 1996).

Rats exposed by inhalation demonstrated eye, nose and skin irritation, degeneration of the nasal epithelium, reduced food consumption, and reduced weight gain (US EPA, 1995; US EPA, 1994b; Miller et al., 1979; 1981; Gage, 1970). High levels administered via drinking water resulted in decreased body and organ weights (US EPA, 1994b).

Dose-related maternal toxicity (nasal irritation and reduced body weight gains) was reported in pregnant rats and rabbits exposed to acrylic acid via inhalation during gestation; no adverse fetal effects were identified (BASF, 1994; Neeper-Bradley and Kubena, 1993; Klimisch and Hellwig, 1991). Chronic oral exposure of acrylic acid administered in drinking water caused decreased water consumption, reduced maternal, fetal, and pup weight gains. No toxicological effects were reported after oral exposure via silage to pregnant cows (Vojtisek et al., 1991). There is limited evidence that oral exposures may also result in adverse reproductive effects (BASF, 1993; DePass, 1983).

Direct application to the skin or the eyes resulted in moderate to severe tissue corrosion and necrosis (BG Chemie, 1991; BASF, 1958; Carpenter et al., 1974). Repeated dermal applications

did not result in sensitization to acrylic acid exposure (BASF, 1958; Rao et al., 1981; Parker and Türk, 1983; Waegemaekers and van der Walle, 1984).

4.1.3.2 Sub-Chronic and Chronic Adverse Health Effects in Humans

No effects of chronic toxicity in humans were identified (BG Chemie, 1991; IPCS, 1997; US EPA, 1994a;b).

4.1.4 Genotoxicity, Mutagenicity, and Carcinogenicity

In vitro mutagenic and genotoxicity testing of acrylic acid produced both negative (Oesch, 1977; Lijinsky and Andrews, 1980; Zeiger et al., 1987; Curren, 1988; Ishidate et al., 1988; McCarthy et al. 1992; Yang, 1988; Wiegand et al., 1989) and positive results (McCarthy et al. 1988; 1992; Moore et al., 1988). There were a limited number of *in vivo* studies. Some of the data demonstrated no mutagenic potential while others were inconclusive (US EPA, 1984; McCarthy et al., 1988; Valencia et al., 1988; BG Chemie, 1991; IPCS, 1997; IARC, 1998).

Few animal studies of the potential carcinogenicity of acrylic acid were found. No human reports were identified. Oral administration of acrylic acid did not produce any carcinogenic effects (BASF, 1989). Dermal application of acrylic acid solution produced no malignancies in mice exposed for a life time (DePass et al., 1984). A second study reported two squamous cell carcinomas in mice without prior initiation by dimethylbenz[a]anthracine (DMBA). Mice with DMBA initiation demonstrated three papillomas and one squamous cell carcinoma (Cote et al., 1986). An independent review of the second study indicated that the results might be questionable due to a number of inconsistencies identified by the reviewers. The tumours may also have been due to the local irritant/corrosive effects of acrylic acid (Sivak, 1987; Wiegand et al., 1989).

The available carcinogenicity data is insufficient to conclude that acrylic acid is not a human carcinogen; however, it does suggest that acrylic acid is not a carcinogenic hazard (McCarthy et al., 1992; IPCS, 1997; ACGIH, 2001;). The International Agency of Research on Cancer (IARC) (1979; 1987; 1998) "classifies acrylic acid as group 3, not classifiable as to its carcinogenicity to humans, based on inadequate human and animal data" (RTECS, 2000; US EPA, 1994b).

4.1.5 Summary

Animal studies demonstrate that acrylic acid is readily absorbed and distributed throughout the body, then rapidly metabolized and excreted primarily as carbon dioxide.

No human metabolic data or human systemic or chronic effects data were identified in the available literature.

Inhalation of acrylic acid is acutely irritating to the eyes, skin, and respiratory system in humans and animals. In rats and mice, acrylic acid is moderately toxic when inhaled or ingested. Inhalation caused irritation of the eyes and nose, lung hemorrhage, and some systemic damage to the liver and kidneys. It is moderately to highly toxic when applied to the skin.

Chronic exposures by inhalation to experimental animals was irritating to eye, nose and skin, damaged nasal and gastric tissues, resulted in reduced of food consumption, and reduced body weight gain. Direct application to the skin or the eyes resulted in moderate to severe tissue corrosion and necrosis.

Dose-related maternal toxicity was also reported in animals exposed via inhalation during gestation; no adverse fetal effects were identified. Chronic oral exposure of acrylic acid caused decreased water consumption, and reduced maternal, fetal, and pup weight gains. There is limited evidence that oral exposures may also have adverse reproductive effects.

Results of mutagenic and genotoxicity testing were mixed. Studies examining the potential carcinogenicity of acrylic acid were inadequate to determine human carcinogenicity.

4.2 Terrestrial Organisms

Acrylic acid is degraded both under aerobic and anaerobic conditions. The toxicity of acrylic acid to soil microorganisms is low. The threshold level for inhibition of growth of the bacterium, *Pseudomonas putida* was 41 mg/L (41 ppm) after exposure for 16 hours to a neutralized solution of acrylic acid (Bringmann and Kühn, 1980). Kay-Shoemake et al. (1998) found that acrylic acid served as the sole carbon source for bacteria in enrichment cultures.

In a study of the effects of acrylic acid on soil carbon cycle, in a sandy loam soil, acrylic acid levels up to 100 mg/kg had no effect on the respiration of soil microflora. However, 1000 mg/kg completely suppressed respiration (Hossack et al. 1992) and presumably organic matter decomposition.

No published reports were found on the effects of acrylic acid on terrestrial vegetation. This conclusion is supported by the previous observation of Rydzynski (1997).

5.0 AIR SAMPLING AND ANALYTICAL METHODS

5.1 Reference Methods

Air sampling and monitoring methods and technologies for acrylic acid used in practice by jurisdictions and established agencies are reported. In general, standard air monitoring methods and technologies for acrylic acid are based on canister sampling or pump-and-tube sampling approaches. Widely employed and accepted referenced air monitoring methods and technologies for acrylic acid have been developed, tested and reported by the United States Environmental Protection Agency (US EPA) and Occupational Safety and Health Administration (OSHA). Refer to Table 5-1 for a description of individual method advantages and disadvantages.

5.1.1 US EPA Compendium Method TO-15A

The US EPA has developed a methodology suitable for sampling ambient air for trace-level concentrations of acrylic acid. US EPA Compendium Method TO-15A describes the determination of VOCs (including acrylic acid) in air collected in specially prepared canisters and analyzed by gas chromatography/mass spectrometry (GC/MS) (US EPA, 1999). The advantages of this method include: incorporates a multisorbent/dry purge technique or equivalent for water management thereby addressing a more extensive set of compounds, establishes method performance criteria for acceptance of data, provides enhanced provisions for quality control, and unique water management approach allows analysis for polar VOCs. Disadvantages of this method are it requires expensive analytical equipment and a high level of operator skill to perform.

In this method, the ambient atmosphere is sampled by introduction of 6 liters (L) of air into a specially prepared stainless steel canister (SUMMA or equivalent) over an appropriate time and rate. Both subatmospheric pressure and pressurized sampling modes make use of an initially evacuated canister. A pump ventilated sampling line is used during sample collection with most commercially available samplers. Pressurized sampling requires an additional pump to provide positive pressure to the sample canister. A sample of air is drawn through a sampling train comprised of components that regulate the rate and duration of sampling into the pre-evacuated and passivated canister. After the air is collected the canister valve is closed, an identification tag is attached to the canister, and the canister is transported to the laboratory for analysis. Upon receipt at the laboratory the canister tag data is recorded and the canister is stored until analysis.

To analyze the sample a known volume of sample is directed from the canister through a solid multisorbent concentrator. A portion of the water vapour in the sample breaks through the concentrator during sampling to a degree depending on the multisorbent composition, duration of sampling, and other factors. Dry purging the concentrator with helium while retaining target compounds can further reduce water content of the sample. After the concentration and drying steps are completed, the VOCs are thermally desorbed, entrained in a carrier gas stream, and then focused in a small volume by trapping on a reduced temperature trap or a small volume multisorbent trap. The sample is then released by thermal desorption and carried onto a gas chromatographic column for separation.

The analytical strategy for US EPA Compendium Method TO-15A involves using a high-resolution gas chromatograph (GC) coupled to a mass spectrometer (MS). If the MS is a linear quadrupole system, it is operated either by continuously scanning a wide range of mass to charge ratios (SCAN mode) or by monitoring select ion monitoring mode (SIM) of compounds on the target list. If the MS is based on a standard ion trap design, only a scanning mode is used. Mass spectra for individual peaks in the total ion chromatogram are examined with respect to fragmentation pattern of ions corresponding to various VOCs including the intensity of primary and secondary ions. The fragmentation pattern is compared with stored spectra taken under similar conditions, in order to identify the compound.

For any given compound, the intensity of the primary fragment is compared with the system response to the primary fragment for known amounts of the compound. This establishes the compound concentration that exists in the sample. This method applies to ambient concentrations of VOCs above 0.5 parts per billion by volume (ppbv or 1 $\mu g/m^3$) and typically requires VOC enrichment by concentrating up to 1 L of a sample volume. The VOC concentration range for ambient air in many cases includes the concentration at which continuous exposure over a lifetime is estimated to constitute a 10^{-6} or higher lifetime risk of developing cancer in humans.

5.1.2 OSHA Method 28

OSHA has developed a fully validated method for the determination of acrylic acid that is suitable for occupational, personal and area monitoring. The current methodology used by the OSHA to determine acrylic acid in air (OSHA Method 28) was developed to be rapid, sensitive and accurate (OSHA, 1981). This method consists of collecting acrylic acid by drawing a known volume of air through two XAD-8 sampling tubes connected in series. Samples are desorbed with methanol/water (1:1) and analyzed by high performance liquid chromatography (HPLC) using an ultraviolet (UV) detector. Advantages of this method include: sensitivity of the analytical method permits sampling times as short as 15 minutes; HPLC analysis of acrylic acid is rapid, direct, and sensitive; and reanalysis of samples is possible.

Sampling is conducted by drawing air through two standard size glass tubes in series packed with approximately 100 milligrams (mg) of XAD-8 solid sorbent (an acrylic ester polymer) each. A personal sampling pump calibrated to within 5% of the recommended flow rate with a sampling tube in line is used. The suggested flow rate is 0.1 liters per minute (L/min) and the recommended volume collected is 24 L after a sampling time of 4 hours. The reliable detection limit of the overall procedure is 1 micrograms (μg) per sample (0.014 parts per million by volume (ppmv) or 0.042 milligrams per cubic meter (mg/m^3)) for a 24 L air sample. This is the amount of acrylic acid spiked on the sampling device that allows recovery of an amount equivalent to the detection limit of the analytical procedure. The reliable quantitation limit is 1 μg per sample (0.014 ppmv or 0.042 mg/m^3). This is the smallest amount of acrylic acid that can be quantified within the requirements of 75% recovery and 95% confidence limits of $\pm$ 25%.

5.1.3 OSHA Method PV2005

OSHA has also developed a partially validated method (i.e. this method has been subjected to established evaluation procedures, and is presented for information and trial use) for acrylic acid

that is suitable for occupational, personal and area monitoring (OSHA Method PV2005) (OSHA, 1996). This method consists of collecting acrylic acid by drawing a known volume of air through two Anasorb-708 sampling tubes connected in series. Samples are desorbed with 2 millilitres (mL) of methanol for 1 hour with shaking and analyzed by high performance liquid chromatography (HPLC) using an ultraviolet (UV) detector.

Sampling is conducted by drawing air through two standard size glass tubes in series packed with one section of 100 mg of Anasorb-708 each. A personal sampling pump calibrated to within 5% of the recommended flow rate with a sampling tube in line is used. The suggested flow rate is 0.1 L/min and the recommended volume collected is 24 L after a sampling time of 4 hours. The reliable detection limit of the overall procedure is 0.064 µg per sample (0.001 ppmv or 0.00267 mg/m^3) for a 24 L air sample. This is the amount of acrylic acid spiked on the sampling device that will give a response that is significantly different than the background response of a sampler blank. The reliable quantitation limit is 0.213 µg per sample (0.00301 ppmv). This is the smallest amount of acrylic acid that can be quantified within the requirements of 75% recovery and 95% confidence limits of ± 25%.

5.2 Alternative, Emerging Technologies

In general, most non-standard methods and technologies are variations or modifications of those referenced methods previously mentioned (Vincent and Guient, 1982; IPCS, 1997). However, a number of unique methods and technologies have been described (Zanella et al., 1999; Peterson et al., 1997). These unique methods and technologies include: a diffusion denuder system and a sampling train test method. Refer to Table 5.1 for a description of individual method advantages and disadvantages.

The most notable variations or modifications of referenced methods for the collection and analysis of acrylic acid involve alternative types of sorbents and analytical techniques to be used in conjunction with the accepted pump-and-tube sampling approaches. Vincent and Guient (1982) suggest detecting concentrations of acrylic acid by collecting air samples on silica gel treated with p-methoxyhydroquinone used as an inhibitor of polymerization. Samples are subsequently desorbed with acetone and analyzed by gas chromatography (GC) using a flame ionization detector (FID). This technique is recommended as a useful method for detection of acrylic acid in occupational environments. The reliable detection limit of the overall procedure is 33 mg/mL of acetone (lower) to 2084 mg/mL acetone (higher). This is equivalent to concentrations ranging from 0.5 ppm to 30 ppm (1.5 – 90 mg/m^3) of acrylic acid in a 48 L sample volume. The largest disadvantage of this technique is that it is significantly affected by humidity changes.

Another method for detecting acrylic acid in air utilizes high performance ion-exclusion chromatography with conductimetric detection (IPCS, 1997). Air is pumped through a florisil tube at a rate of 1 L/min. The collected sorbent is subsequently mixed with water and H_2SO_4 prior to injection into the chromatographic system. The analytical system uses benzoic acid as the mobile phase to allow for the separation of acrylic acid from propionic acid and other aliphatic acids. The reliable detection limit of the overall procedure is 1 mg/m^3 of acrylic acid in a 10 L sample volume. This method is rapid, easy and appears to be suitable for the

determination of acrylic acid when present in industrial emissions containing other aliphatic acids.

A unique method for the determination of atmospheric acrylic acid at the micro to milligram level has recently been described (Zanella et al., 1999). This method is based on diffusion sampling and is designed to discriminate gaseous analytes from their particulate counterparts. Acrylic acid is collected with an efficiency of >98% in tubular denuders coated with sodium hydroxide-barium hydroxide-hydroquinone monomethyl ether, and analyzed by high performance liquid chromatography (HPLC) with ultraviolet (UV) absorbance detection. The reliable detection limit of the overall procedure is 2.9 $\mu g/m^3$ of acrylic acid at a flow rate of 0.5 L/min and a 30 min sampling time (15 L sample volume). This method was developed to monitor workplace atmospheres as well as ambient air in industrial environments.

The US EPA and Research Triangle Institute are currently developing a test method for the collection and measurement of acrylics (including acrylic acid) from stationary source emissions both upstream from (or in the absence of) a control device, where concentrations in the ppm range are expected, and downstream from a control device, where concentrations in the ppb range are expected (Peterson et al., 1997). The sampling train for the collection of acrylics at high concentrations (ppm) consists of a heated sampling probe, two condensate traps in an ice bath, followed by two sorbent tubes packed with 3 grams (front) and 1.5 grams (back) of Carbopack B.

Acrylic acid is collected in the condensate of the knockout traps and is measured by gas chromatography with flame ionization detection (GC-FID). For collection of acrylics at low concentrations (ppb), the sampling train contains a single sorbent tube packed with 0.45 grams of Carbotrap (front) and 0.45 grams of Carboxen 1000 (back). Acrylic acid in the condensate may be concentrated for analysis by means of a solid-phase extraction resin (LCSAX). Acrylic acid concentrations are determined by GC-FID. The approximate analytical limit of quantitation for a 20 L sample is 110 ppb for acrylic acid.

Table 5-1 Method Advantages and Disadvantages

Method	Advantages	Disadvantages
US EPA Compendium Method TO-15A	• Addresses a large set of compounds • Establishes method performance criteria for acceptance of data • Provides quality control provisions • Allows analysis for polar VOCs	• Requires expensive analytical equipment • Requires high level of operator skill
OSHA Method 28	• Short sampling times • Can perform analysis more than once • Rapid and precise • Method is selective and sensitive	NA
OSHA Method PV2005	NA	NA
Silica gel sorbent and GC-FID	NA	• Significantly affected by humidity
Conductimetric detection	• Rapid and easy • Suitable for the determination of acrylic acid when present in industrial emissions containing other aliphatic acids	NA
Diffusion Denuder System	• Useful for workplace atmospheres and ambient air in industrial environments • Can discriminate gaseous analytes from their particulate counterparts	• Experimental
Sampling Train	• Low detection limit	• Experimental

*NA denotes not available.

6.0 AMBIENT GUIDELINES

Current and/or recommended and proposed ambient guidelines of other jurisdictions in Canada, United States and elsewhere were reviewed for acrylic acid. Guidelines that exist for the jurisdictions reviewed are presented in Table 6-1. A complete listing of jurisdictions that were reviewed is found in Appendix A. In general, all jurisdictions have common uses for their guidelines in practice. These uses may include:

- reviewing permit applications for sources that emit air pollutants to the atmosphere,
- investigating accidental releases or community complaints about adverse air quality for the purpose of determining follow-up or enforcement activity,
- determining whether to implement temporary emission control actions under persistent adverse air quality conditions of a short-term nature

The three principal approaches by which guidelines are developed for substances include:

- Using an occupational exposure level (OEL) and dividing it by safety or adjustment factors. The most common OEL used by most state agencies is the 8-hour threshold limit value (TLV) of 5900 $\mu g/m^3$ (2 ppm) adopted by the American Conference of Governmental Industrial Hygienists (ACGIH). The safety or adjustment factors are intended to account for issues such as: differences between eight-hour exposures in the workplace and continuous 24-hour environmental exposures, increased susceptibility of some people in the general population versus the relatively healthy worker, and uncertainty in the margin of safety provided in an occupational exposure limit.
- Using non-carcinogenic risk assessment procedures. A no observed adverse effect level (NOAEL) – or lowest observed adverse effect level (LOAEL) if a NOAEL is unavailable – from a suitable animal or human study is used. It is then divided by a series of adjustment factors. The adjustment factors are intended to account for issues such as: differences between animals and humans, sensitivity of high risk individuals, use of a LOAEL instead of a NOAEL, and for extrapolation from less-than-lifetime exposures to chronic exposure.
- Using carcinogenic risk assessment procedures. Pre-existing cancer risk assessments performed by others (e.g. US EPA Integrated Risk Information System summary data) are used to establish ambient air levels based on acceptable levels of lifetime cancer risk, such as one in 100,000 (10^{-5}). In the case of acrylic acid, there are no jurisdictions that treat this substance as having a potential to cause cancer. Therefore, this approach does not apply to acrylic acid.

For the most part, the guidelines in Table 6-1 are derived based on nasal irritation/degeneration of the nasal olfactory epithelium observed in laboratory animals, or the American Conference of Governmental Industrial Hygienists (ACGIH) 8-hour time weighted average occupational exposure limit (OEL) of 5,900 $\mu g/m^3$ (2 ppm). These guidelines apply to averaging times of 1-hour to annual (continuous exposure duration). Further information on how these guidelines were developed and how they are used in practice is provided in Appendix A.

6.1 Canada

This review did not identify any agencies in Canada that had ambient air guidelines for acrylic acid.

6.2 United States

The US EPA developed a chronic inhalation reference concentration (RfC) of 1 $\mu g/m^3$ (0.34 ppb) applicable to continuous exposure duration (US EPA, 2002). The RfC is based on a 13-week (sub-chronic) inhalation exposure study using mice and a LOAEL 5 ppm (14,900 $\mu g/m^3$) for injury to the nasal olfactory epithelium. The RfC is intended for use by US EPA staff in risk assessments, decision-making and regulatory activities.

In general, most of the other US (state) agencies reviewed have adopted or derived their values from the US EPA (i.e. the RfC) applicable to continuous exposure duration. The California Environmental Protection Agency (CaL EPA) use the same principal data to derive a chronic reference exposure level (REL) applicable to continuous exposure duration (California OEHHA/ARB, 2001). In addition, Cal EPA derived an acute REL based on nasal irritation in rats during an inhalation study with exposure duration of 6 hr/day on 20 occasions (Cal EPA, 1999). The acute REL is applicable to a one-hour duration for humans.

Four US (state) agencies listed in Table 6-1 – New Hampshire, Ohio, Oklahoma, and Texas – use the American Conference of Governmental Industrial Hygienists (ACGIH) 8-hour time weighted average occupational exposure limit (OEL) of 5,900 $\mu g/m^3$ (2 ppm) in development of various ambient guidelines for acrylic acid applicable to different averaging times (refer to Appendix A). It was not possible to report the derivation basis for ambient guidelines used by two US (state) agencies – 8 hour ambient air standard (AAS) of 140 $\mu g/m^3$ (48 ppb) (Louisiana) and a 24-hour ambient air concentration (AAC) 141 $\mu g/m^3$ (48 ppb) (Louisiana) – refer to Appendix A.

6.3 International Agencies

The International Programme on Chemical Safety (IPCS, 1997) recommended an ambient air guideline of 54 $\mu g/m^3$ (18 ppb) for continuous exposures to the general population. This recommendation is intended to assist national and international authorities in making risk assessment and risk management decisions about acrylic acid and not for regulation or standard setting purposes. The New Zealand Ministry of Environment and Ministry of Health recently proposed guidelines for selected air toxics; however, acrylic acid was not included (New Zealand, 2000).

Table 6-1 Summary of Air Quality Guidelines for Acrylic Acid (refer to Appendix A for agency reference)

Agency	Guideline Title	Guideline Value [µg/m³] Averaging Time:			
		1-hour	8-hour	24-hour	annual
US EPA	Reference Concentration (RfC):				1
California EPA	Acute reference exposure level (REL):	6,000			
	Chronic REL:				1
Louisiana DEQ	Ambient air standard (AAS):		140		
Michigan DEQ	Initial threshold screening level (ITSL):			1	
New Hampshire DES	24-hour ambient air limit (AAL):			21	
	Annual AAL:				1
New Jersey DEP	Risk assessment approach is used: Hazard quotient (HQ) of 1 is calculated using US EPA RfC:				1
Ohio EPA	Maximum acceptable ground-level concentration (MAGLC):[1]	59			
Oklahoma DEQ	Maximum acceptable ambient concentration (MAAC):			59	
Texas Natural Resource Conservation Commission (TRNCC)	Effects screening level (ESL):	60			6
Wisconsin DNR	Ambient air concentration (AAC):[1]			141	
	Reference Concentration:1				1
International Programme on Chemical Safety (World Health Organization)	Ambient air guidance value recommended for general population:				54

[1].Proposed.

Note: 1 µg/m³ = 0.34 ppb (conversion factor for acrylic acid at a temperature of 25°C and an atmospheric pressure of 1 atm).

7.0 DISCUSSION

When establishing an ambient air guideline in the form of a concentration limit with a corresponding duration (i.e. averaging time), a number of factors may be taken into account for an air pollutant:

- nature of adverse health effects and conditions of exposure (e.g. exposure concentrations and duration) associated with these effects,
- estimated or actual degree of exposure of receptors, and in particular receptor groups that may be sensitive to the air pollutant,
- available technologies and associated economics for routinely or periodically monitoring for the pollutant in air,
- suitability of approaches for screening and estimating ambient ground-level concentrations in order to compare to the guidelines for permit applications or other situations

Most of the factors, except estimated or actual degree of exposure, have been discussed for acrylic acid. Ambient air guidelines in the form of a short-term (acute) and long-term (chronic) duration are discussed below for acrylic acid. The intent of such guidelines is to address exposures related to humans, animals and vegetation. No direct exposure-related information was obtained for vegetation (Section 4), therefore the discussion emphasizes humans and animals (as surrogates for human exposures).

7.1 Acute Exposure Conditions

As discussed in Section 4, inhalation of acrylic acid can be acutely irritating to the eyes, skin, and respiratory system in humans and animals. In addition, acrylic acid has been shown to be moderately toxic to mice and rats when inhaled at high levels, causing irritation of eyes and nose, lung hemorrhage, and systemic damage to liver and kidneys. Several of the agencies reviewed have an air quality guideline for acrylic acid for acute exposure conditions. California EPA adopted a 1-hour guideline based upon nasal irritation in rats. In addition, two agencies in the US (Ohio EPA and Texas NRCC) use a 1-hour guideline for acrylic acid derived from occupational exposure limits (OELs). Michigan DEQ, New Hampshire DES, Oklahoma DEQ, and Wisconsin DNR have adopted or proposed 24-hour guidelines for acrylic acid from OELs.

The use of OELs for the development of ambient guidelines requires further discussion. There are limitations in the direct application of OELs for ambient air quality guidelines for a number of reasons:

- OELs are based on the information gathered in workplace, through experience from medical research and practice, from experimental human and animal studies, and from a combination of these sources. Often they are based upon averaged tolerated doses from actual repeated industrial exposures. In this respect, they would be considered very accurate at predicting human adverse health effects in industrial exposure situations.
- OELs are determined for a population of workers who are essentially healthy and who fall within a working age group of about 17 to 65 years. These individuals are supposedly in the

prime of life, and potentially less susceptible to the effects of hazardous substances than other members of the public. Individuals vary in sensitivity or susceptibility to hazardous substances, with the elderly and infants in general being more susceptible than healthy workers.

- For most substances, a worker during a normal work schedule (8 hours per day, 5 days per week) receives 40 hours of exposure per week with daily breaks and extended weekend periods in which the body may rid itself of the accumulated substances before elevated levels are reached. For a person living continuously in an environment containing such substances; however, these recovery periods do not exist.

For these reasons, agencies using OELs have a policy of adjusting them downward with the use of safety or adjustment factors to derive guidelines for environmental (ambient) settings. The OELs are considered surrogates for benchmark values for ambient exposures only because they tend to be based upon a large body of toxicological, epidemiological, and/or clinical evidence pertaining to human exposure (albeit in the workplace). Uncertainty exists in terms of whether too much (or too little) safety is inherent in ambient air guidelines developed from OELs.

7.2 Chronic Exposure Conditions

Chronic inhalation exposures have been shown to be irritating to the eye, nose and skin, and to damage nasal tissue in experimental animals (Section 4). Studies examining the potential carcinogenicity of acrylic acid were inadequate to determine human carcinogenicity. However, the current practice requires strong evidence to conclude that a chemical is not carcinogenic in humans, usually including adequate chronic bioassays in at least two species. Based on the lack of this type of data, it cannot be definitively concluded that acrylic acid can cause cancer in humans, although substantial relevant data suggests that it does not (IPCS, 1997).

Numerous agencies have an annual guideline of 1 $\mu g/m^3$ (0.34 ppb), including US EPA, California EPA, New Hampshire DES, New Jersey DEP, and Wisconsin DNR. This guideline was derived from a LOAEL (lowest-observed-adverse-effects level) endpoint obtained from a mice sub-chronic test and further adjusted with an uncertainty factor of 300. The International Programme on Chemical Safety (IPCS, 1997) essentially used the same LOAEL endpoint and made further adjustments with an uncertainty factor of 50 to recommend an ambient air guideline of 54 $\mu g/m^3$ (18 ppb) for chronic exposure.

8.0 REFERENCES

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APPENDIX A

REVIEW OF AIR QUALITY GUIDELINES FOR ACRYLIC ACID USED BY AGENCIES IN NORTH AMERICA AND ELSEWHERE

Agency: Ontario Ministry of the Environment (OME).
Acrylic Acid Air Quality Guideline: Ontario Ministry of the Environment does not have an ambient air guideline for this chemical.
Averaging Time To Which Guideline Applies: n/a
Basis for Development: n/a
Date Guideline Developed: n/a
How Guideline is Used in Practice: n/a
Additional Comments: n/a
Reference and Supporting Documentation: n/a

Agency: US Agency for Toxic Substances and Disease Registry (ATSDR).
Acrylic Acid Air Quality Guideline: ATSDR does not have an ambient air guideline for this chemical.
Averaging Time To Which Guideline Applies: n/a
Basis for Development: n/a
Date Guideline Developed: n/a
How Guideline is Used in Practice: n/a
Additional Comments: n/a
Reference and Supporting Documentation: Agency for Toxic Substances and Disease Registry (ATSDR). 2002. Minimal Risk Levels (MRLs) for Hazardous Substances. ATSDR, Public Health Service, US Department of Health and Human Services. Atlanta, GA. Available at: http://www.atsdr.cdc.gov/mrls.html (accessed 18 February 2002).

Agency: US Environmental Protection Agency (EPA).
Acrylic Acid Air Quality Guideline: Reference concentration (RfC) = 1 $\mu g/m^3$ (0.34 ppb).
Averaging Time To Which Guideline Applies: Continuous exposure (daily exposure over a lifetime).
Basis for Development: The RfC was developed as follows. As reported in the Integrated Risk Information System (IRIS), a 13-week (sub-chronic) inhalation exposure study using mice identified a LOAEL of 5 ppm (14.9 mg/m^3) based on degeneration of the nasal olfactory epithelium. After making adjustments for exposure duration and a gas:respiratory effect, a human equivalent concentration (HEC) of 330 $\mu g/m^3$ was calculated and further adjusted with an uncertainty factor of 300 to derive an RfC of 1 $\mu g/m^3$ (after rounding).
Date Guideline Developed: Last revised in 1995.
How Guideline is Used in Practice: The reference concentration (RfC) is intended for use by US EPA staff in risk assessments, decision-making and regulatory activities.
Additional Comments: The Integrated Risk Information System (IRIS) is prepared and maintained by the US EPA. IRIS is an electronic database containing information on human health effects that may result from exposure to various chemicals in the environment.
Reference and Supporting Documentation: US Environmental Protection Agency. Integrated Risk Information System. http://www.epa.gov/iris/ (accessed 18 February 2002).

Agency: California Environmental Protection Agency (Cal EPA).
Acrylic Acid Air Quality Guideline: Acute reference exposure level (REL) = 6,000 µg/m³ (2,040 ppb) [1-hour averaging time]. Chronic reference exposure level (REL) = 1 µg/m³ (0.34 ppb) [continuous (daily) exposure over a lifetime].
Averaging Time To Which Guideline Applies: See above.
Basis for Development: Basis for the acute REL was nasal irritation in rats during an inhalation study with exposure duration of 6 hr/day on 20 occasions. Exposure concentrations equivalent to a one-hour duration for humans were extrapolated using a "toxic load" (concentration x time) formula. The acute REL was calculated by using an extrapolated one-hour concentration of 200 ppm (600 mg/m³) and dividing it by a cumulative uncertainty factor of 100. The chronic REL is based on the US EPA reference concentration (RfC) limit of 1 µg/m³.
Date Guideline Developed: Acute REL – March 1999. Chronic REL – 1996.
How Guideline is Used in Practice: Acute and chronic RELs are for use in facility health risk assessments conducted for the AB 2588 Air Toxics "Hot Spots" Program.
Additional Comments: n/a
Reference and Supporting Documentation: California Environmental Protection Agency (Cal EPA). 1999. Determination of Acute Reference Exposure Levels for Airborne Toxicants. Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology Section, Cal EPA. Oakland, CA. March 1999. California Office of Environmental Health Hazard Assessment (OEHHA)/Air Resources Board (ARB). 2001. Approved Chronic Reference Exposure Levels and Target Organs. Table 3 (last updated 13 September 2001). Available at: www.arb.ca.gov/toxics/healthval/chronic.pdf (accessed 18 February 2002).

Agency: Louisiana Department of Environmental Quality (DEQ).
Acrylic Acid Air Quality Guideline: Ambient air standard (AAS) for toxic air pollutants = 140 $\mu g/m^3$ (48 ppb)
Averaging Time To Which Guideline Applies: 8-hour averaging time.
Basis for Development: Not stated.
Date Guideline Developed: Not stated.
How Guideline is Used in Practice: AASs are used by Louisiana DEQ to review permit applications for stationary sources that emit acrylic acid to the atmosphere.
Additional Comments: n/a
Reference and Supporting Documentation: *Louisiana Administrative Code (LAC). Title 33 Environmental Quality, Part III Air, Chapter 51. Comprehensive Toxic Air Pollutant Emission Control Program. Louisiana Department of Environmental Quality. Baton Rouge, LA.*

Agency: Massachusetts Department of Environmental Protection (DEP).
Acrylic Acid Air Quality Guideline: Massachusetts DEP does not have an ambient air guideline for this chemical.
Averaging Time To Which Guideline Applies: n/a
Basis for Development: n/a
Date Guideline Developed: n/a
How Guideline is Used in Practice: n/a
Additional Comments: n/a
Reference and Supporting Documentation: Massachusetts Department of Environmental Protection (DEP). 1995. Revised air guidelines [updated list of 24-hour average Threshold Effects Exposure Limit (TEL) values and annual average Allowable Ambient Limit (AAL) values]. Massachusetts DEP, Boston, MA. 6 December 1995. Memorandum available at: http://www.state.ma.us/dep/ors/files/aallist.pdf (accessed 18 February 2002).

Agency: Michigan Department of Environmental Quality (DEQ).
Acrylic Acid Air Quality Guideline: Initial threshold screening level (ITSL) = 1 μg/m³ (0.34 ppb).
Averaging Time To Which Guideline Applies: 24-hour averaging time.
Basis for Development: The ITSL is based on the US EPA reference concentration (RfC) limit of 1 μg/m³.
Date Guideline Developed: 1994.
How Guideline is Used in Practice: There are two basic requirements of Michigan air toxic rules. First, each source must apply the best available control technology for toxics (T-BACT). After the application of T-BACT, the emissions of the toxic air contaminant cannot result in a maximum ambient concentration that exceeds the applicable health based screening level for non-carcinogenic effects (ITSL). Application of an ITSL is required for any new or modified emission source or sources for which a permit to install is requested and which emits a toxic air contaminant.
Additional Comments: The applicable air quality screening level for chemical treated as non-carcinogens by Michigan DEQ is the ITSL. There are two health based screening levels for chemical treated as carcinogens by Michigan DEQ: the initial risk screening level (IRSL) – based on an increased cancer risk of one in one million, and the secondary risk screening level (SRSL) – based on as an increased cancer risk of 1 in 100,000.
Reference and Supporting Documentation: Michigan Administrative Code (MAC). Air Pollution Control Rules. Part 2 Air Use Approval, R 336.1201 - 336.1299. Air Quality Division, Department of Environmental Quality. Lansing, MI.

Agency: New Hampshire Department of Environmental Services (DES).
Acrylic Acid Air Quality Guideline: 24-hour ambient air limit (AAL) = 21 $\mu g/m^3$ (7 ppb). Annual ambient air limit (AAL) = 1 $\mu g/m^3$ (0.34 ppb).
Averaging Time To Which Guideline Applies: See above.
Basis for Development: In the case of acrylic acid, the AALs were developed in the following manner: 24-hour Ambient Air Limit – The American Conference of Governmental Industrial Hygienists (ACGIH) 8-hour time weighted average occupational exposure limit (OEL) of 5.9 mg/m^3 (2 ppm) is divided by a safety factor (SF) of 100 and a time adjustment factor (TAF) of 2.8. Annual Ambient Air Limit – The reference concentration (RfC) limit established by the US EPA is used as the annual AAL.
Date Guideline Developed: May 1998.
How Guideline is Used in Practice: AALs are used by New Hampshire DES to review permit applications for sources that emit acrylic acid to the atmosphere. Sources are regulated through a statewide air permitting system and include any new, modified or existing stationary source, area source or device.
Additional Comments: n/a
Reference and Supporting Documentation: *New Hampshire Administrative Rule. Chapter Env-A 1400. Regulated Toxic Air Pollutants. New Hampshire Department of Environmental Services. Concord, NH.*

Agency: New Jersey Department of Environmental Protection (DEP).
Acrylic Acid Air Quality Guideline: Applicants are required to carry out a risk assessment in conjunction with applying for an air pollution control pre-construction permit. In the case of acrylic acid, the US Environmental Protection Agency RfC (1 $\mu g/m^3$) (0.34 ppb) is used as the pollutant-specific reference concentration in which to calculate a Hazard Quotient for sources that emit acrylic acid to the atmosphere.
Averaging Time To Which Guideline Applies: Continuous (daily) exposure over a lifetime.
Basis for Development: Based on US EPA Integrated Risk Information System (IRIS) data.
Date Guideline Developed: December 1994.
How Guideline is Used in Practice: Used by New Jersey DEP to review permit applications for sources that emit acrylic acid to the atmosphere.
Additional Comments: n/a
Reference and Supporting Documentation: New Jersey Administrative Code (NJAC). Title 7, Chapter 27, Subchapter 8. Permits and Certificates for Minor Facilities (and Major Facilities without an Operating Permit). New Jersey Department of Environmental Protection. Trenton, NJ. New Jersey Department of Environmental Protection. 1994. Technical Manual 1003. Guidance on Preparing a Risk Assessment for Air Contaminant Emissions. Air Quality Permitting Program, Bureau of Air Quality Evaluation, New Jersey Department of Environmental Protection. Trenton, NJ. Revised December 1994.

Agency: North Carolina Department of Environment and Natural Resources (ENR).
Acrylic Acid Air Quality Guideline: North Carolina ENR does not have an ambient air guideline for this chemical.
Averaging Time To Which Guideline Applies: n/a
Basis for Development: n/a
Date Guideline Developed: n/a
How Guideline is Used in Practice: n/a
Additional Comments: n/a
Reference and Supporting Documentation: North Carolina Administrative Code (NCAC). North Carolina Air Quality Rules 15A NCAC 2D.1100 – Air Pollution Control Requirements (Control of Toxic Air Pollutants). North Carolina Department of Environment and Natural Resources. Raleigh, NC. *North Carolina Administrative Code (NCAC). North Carolina Air Quality Rules 15A NCAC 2Q.0700 – Air Quality Permit Procedures (Toxic Air Pollutant Procedures). North Carolina Department of Environment and Natural Resources. Raleigh, NC.*

Agency:

Ohio Environmental Protection Agency (EPA).

Ammonia Air Quality Guideline:

Maximum acceptable ground-level concentration (MAGLC) = 59 µg/m³ (20 ppb) (proposed).

Averaging Time To Which Guideline Applies:

1-hour averaging time.

Basis for Development:

$$\text{MAGCL} = \frac{\text{TLV}}{10} \times \frac{8\text{ hr}}{24\text{ hr}} \times \frac{5\text{ d}}{7\text{ d}} \times \frac{30\text{ yr}}{70\text{ yr}} = \frac{\text{TLV}}{100}.$$

The TLV is the ACGIH 8-hour time weighted average occupational exposure limit (OEL) of 5.9 mg/m³ (2 ppm). The TLV is adjusted by a safety factor of 10 to take into account greater susceptibility of the general population in comparison to healthy workers. The 8/24 and the 5/7 multipliers are used to relate the exposure to longer than 40-hour time periods and ascertain that the individual's total exposure will be no greater than that allowed by the TLV. The 30/70 multiplier is used to relate the difference in exposure duration from a possible working lifetime of 30 years to the average life exposure assumption of 70 years.

Date Guideline Developed:

January 1994 (proposed).

How Guideline is Used in Practice:

Used by Ohio EPA to review permit applications for sources that emit acrylic acid to the atmosphere.

Additional Comments:

n/a

Reference and Supporting Documentation:

Ohio Environmental Protection Agency (Ohio EPA). 1994. Review of New Sources of Air Toxic Emissions. Proposed for Public Comment. Division of Air Pollution Control, Ohio EPA. Columbus, OH. January 1994. 31 pp.

Agency: Oklahoma Department of Environmental Quality (DEQ).
Acrylic Acid Air Quality Guideline: Maximum acceptable ambient concentration (MAAC) = 59 µg/m³ (20 ppb).
Averaging Time To Which Guideline Applies: 24-hour averaging time.
Basis for Development: The ACGIH TLV – 8-hour time weighted average occupational exposure limit (OEL) of 5.9 mg/m³ (2 ppm) – is divided by a safety factor of 100.
Date Guideline Developed: Not stated.
How Guideline is Used in Practice: MAACs are used by Oklahoma DEQ to review permit applications for sources that emit acrylic acid to the atmosphere.
Additional Comments: n/a
Reference and Supporting Documentation: *Oklahoma Administrative Code (OAC). Title 252. Chapter 100. Air Pollution Control. 100:252-41 - Control of Emission of Hazardous and Toxic Air Contaminants. Oklahoma Department of Environmental Quality. Oklahoma City, OK.* Oklahoma Department of Environmental Quality (DEQ). 2002. Air Toxics Partial Listing [maximum acceptable ambient concentrations (MAAC) for air toxics]. Oklahoma City, OK. Available at: http://www.deq.state.ok.us/AQDNew/toxics/listings/pollutant_query_1.html (accessed 21 February 2002).

Agency: Rhode Island Department of Environmental Management (DEM).
Acrylic Acid Air Quality Guideline: Rhode Island DEM does not have an ambient air guideline for this chemical.
Averaging Time To Which Guideline Applies: n/a
Basis for Development: n/a
Date Guideline Developed: n/a
How Guideline is Used in Practice: n/a
Additional Comments: n/a
Reference and Supporting Documentation: *Rhode Island Department of Environmental Management. 1992. Air Pollution Control Regulation No. 22. Division of Air and Hazardous Materials, Rhode Island Department of Environmental Management. Providence, RI. Amended 19 November 1992.*

Agency: Texas Natural Resource Conservation Commission (TRNCC).
Acrylic Acid Air Quality Guideline: Short-term effects screening level (ESL) = 60 µg/m³ (20 ppb). Long-term effects screening level (ESL) = 6 µg/m³ (2 ppb).
Averaging Time To Which Guideline Applies: 1-hour averaging time for short-term ESL. Annual averaging time for long-term ESL.
Basis for Development: Short-term Effects Screening Level – The ACGIH TLV – 8-hour time weighted average occupational exposure limit (OEL) of 5.9 mg/m³ – is divided by a safety factor of 100 and rounded. Long-term Effects Screening Level – The ACGIH TLV – 8-hour time weighted average occupational exposure limit (OEL) of 5.9 mg/m³ – is divided by a safety factor of 1000 and rounded.
Date Guideline Developed: Not stated.
How Guideline is Used in Practice: ESLs are used to evaluate the potential for effects to occur as a result of exposure to concentrations of constituents in air. ESLs are based on data concerning health effects, odor nuisance potential, effects with respect to vegetation, and corrosion effects. They are not ambient air standards. If predicted or measured airborne levels of a chemical do not exceed the screening level, adverse health or welfare effects would not be expected to result. If ambient levels of constituents in air exceed the screening levels, it does not necessarily indicate a problem, but rather, triggers a more in-depth review.
Additional Comments: n/a
Reference and Supporting Documentation: Texas Natural Resource Conservation Commission (TNRCC) 2001. Toxicology & Risk Assessment (TARA) Section Effects Screening Levels. http://www.tnrcc.state.tx.us/permitting/tox/index.html (accessed 18 February 2002).

Agency: Vermont Agency of Natural Resources (ANR).
Acrylic Acid Air Quality Guideline: Vermont ANR does not have an ambient air guideline for this chemical.
Averaging Time To Which Guideline Applies: n/a
Basis for Development: n/a
Date Guideline Developed: n/a
How Guideline is Used in Practice: n/a
Additional Comments: n/a
Reference and Supporting Documentation: Vermont Air Pollution Control Regulations. 2001. State of Vermont Agency of Natural Resources. Air Pollution Control Division. Waterbury, VT. 29 November 2001. 187 pp.

Agency: Washington State Department of Ecology (DOE).
Acrylic Acid Air Quality Guideline: Washington State DOE does not have an ambient air guideline for this chemical.
Averaging Time To Which Guideline Applies: n/a
Basis for Development: n/a
Date Guideline Developed: n/a
How Guideline is Used in Practice: n/a
Additional Comments: n/a
Reference and Supporting Documentation: *Washington Administrative Code (WAC). Chapter 173-460 WAC. Controls For New Sources Of Toxic Air Pollutants. Washington State Department of Ecology. Olympia, WA.*

Agency: Wisconsin Department of Natural Resources (DNR).
Acrylic Acid Air Quality Guideline: Ambient air concentration (AAC) = 141 µg/m³ (48 ppb) (proposed) [24-hour averaging time]. Reference concentration (RfC) = 1 µg/m³ (0.34 ppb) (proposed) [continuous (daily) exposure over a lifetime].
Averaging Time To Which Guideline Applies: See above
Basis for Development: The basis for the 24-average AAC proposed for acrylic acid is unknown. The US EPA reference concentration of 1 µg/m³ is proposed as a long-term exposure criterion.
Date Guideline Developed: Not stated.
How Guideline is Used in Practice: AACs and the RfC are used by Wisconsin DNR to review permit applications for sources that emit acrylic acid to the atmosphere.
Additional Comments: n/a
Reference and Supporting Documentation: *Wisconsin Administrative Code (WAC). Air Pollution Control Rules. Chapter NR 445. Control of Hazardous Pollutants. Wisconsin Department of Natural Resources. Madison WI.*

Agency: New Zealand Ministry for the Environment and New Zealand Ministry of Health.
Acrylic Acid Air Quality Guideline: Ambient air quality guidelines are proposed for selected air toxics; however, acrylic acid is not included.
Averaging Time To Which Guideline Applies: n/a
Basis for Development: n/a
Date Guideline Developed: n/a
How Guideline is Used in Practice: n/a
Additional Comments: n/a
Reference and Supporting Documentation: New Zealand Ministry for the Environment and Ministry of Health (New Zealand). 2000. Proposals for Revised and New Ambient Air Quality Guidelines. Discussion Document. Air Quality Technical Report No 16. Prepared by the Ministry for the Environment and the Ministry of Health. December 2000. 86 pp.

Agency:

International Programme on Chemical Safety (World Health Organization - WHO)

Acrylic Acid Air Quality Guideline:

An ambient air guidance value of 54 $\mu g/m^3$ (18 ppb) was recommended for the general population.

Averaging Time To Which Guideline Applies:

Continuous (daily) exposure over a lifetime.

Basis for Development:

In a subchronic (13-week) inhalation study, lesions were observed in the nasal epithelium in rats at 225 mg/m^3 (75 ppm) and in mice at 15 mg/m^3 (5 ppm). The LOAEL of 15 mg/m^3 (5 ppm) was used as the basis for an inhalation guidance value. Uncertainty factors (UFs) of 5 for inter-individual differences and 10 as a composite UF for interspecies, LOAEL to NOAEL and subchronic to chronic extrapolations were applied.

The inhalation guidance value for the general population was calculated as follows:
$= 15 mg/m^3 \times (6/24) \times (5/7) \times (1/50) = 54 \mu g/m^3$, where:
15 mg/m^3 = LOAEL for mice
6/24 and 5/7 = duration of exposure in hr/d and week/day, respectively
50 = total uncertainty factor

Date Guideline Developed:

1996.

How Guideline is Used in Practice:

The publication – Environmental Health Criteria 191: Acrylic Acid – is intended to assist national and international authorities in making risk assessment and risk management decisions. Recommendations made in the publication, in particular the guidance value of 54 $\mu g/m^3$ for ambient air for the general population – is not a recommendation for regulation or standard setting.

Additional Comments:

The International Programme on Chemical Safety (IPCS), established in 1980, is a joint program of three cooperating organizations - United Nations Environment Programme (UNEP), the International Labour Organisation (ILO), and the World Health Organization (WHO), implementing activities related to chemical safety. The World Health Organization is the executing agency of the IPCS.

Reference and Supporting Documentation:

International Programme on Chemical Safety (IPCS). 1997. Environmental Health Criteria 191: Acrylic Acid. World Health Organization, IPCS. Geneva, Switzerland. 106 pp.